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EXPERIMENTAL STUDY ON STABILIZATION OF BLACK COTTON SOIL BY USING LIME AND BRICK DUST

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Abstract –*now a day's many studies have taken place for improving the stability of black cotton soil because of its geo technical characteristics i.e. it shrinks in the absence of moisture and swells in the presence of moisture because of this reason it is difficult for the civil engineers to design and construct structures in black cotton soil. Many admixture like flyash GGBS and many other admixtures are used to improve the geo technical properties of black cotton soil .present study is done on improving the geo technical properties of black cotton soil using lime and brick dust because disposal and management of demolition waste is one of the major problem now days, that waste can be used for betterment of characteristics of black cotton soil. This study consists of determination of physical properties of black cotton soil, change in the geo technical properties of black cotton soil by the addition of lime and brick dust in varying percentage.*

Key Words: *Black cotton soil, Ground improvement by stabilization, Lime, Brick dust, Waste disposal.*

1. INTRODUCTION

The economic development of a country depends on the infrastructure facilities available. Roadways and railways have been some of the important infrastructure facilities for moving of goods and services within the country. Construction of highways has been an important task where several challenges are encountered from human inference and nature.

In India 20% of the surfaces are covered with expansive soils. The main type of of expansive soil in India is black cotton soil .the major problem with black cotton soil are swelling and shrinkage characteristics the black cotton soil swells when come in contact with the water and shrinks on drying. Due to repeated swelling and shrinkage of soil, cracks develops because of that permeability increases. Due to this characteristics of black cotton soil leads to severe damage in civil engineering structure as cracking in buildings or total distraction of the structure, structural elements and in pavements. Hence it is essential to improve the the geo-technical properties of black cotton soil.

Disposal of the industrial waste material is essential as these are causing hazardous effects on environment. Utilization of industrial and agricultural waste products in stabilization soil is the recent focus of research because of economic, environmental and technical reasons.

1.1 Black cotton soil

Expansive soil commonly known as black cotton soil because of their color and their suitability for growing cotton. Design and construction of civil engineering structures on and with expansive soil is a challenging task for geotechnical and civil engineers. Expansive soil is considered as most problematic soil as compare to other type of soils .due their behavior of change in volume with the variation in moisture content elastic deformation takes place .i.e. cause damage to the structure due swelling in rainy season and shrinkage in summer : building cracks, canal lining slide, beds of canal heave , roads get rutted etc. Physical properties of black cotton soil are listed in table .1

Table.1 Physical properties of black cotton soil.

Properties	Black cotton soil
Color	Black
Specific gravity	2.4
GRAIN SIZE DISTRIBUTION	
Fine sand (%)	7
Silt (%)	17
Clay (%)	76
ATTERBERG'S LIMIT	
Liquid limit (%)	78
Plastic limit (%)	47.13
COMPACTION CHARACTERISTICS	
Maximum dry density (kN/m^3)	11.51
Optimum moisture content (%)	18
Unconfined compression strength (kN/m^2)	145.5
California bearing ratio	1.2

1.2 Soil stabilization

Stabilization may be defined as any process by which a soil material is improved and made more stable. Soil

stabilization is the treatment of natural soil to improve its engineering properties. The goals of stabilization are to improve the soil strength, to improve the bearing capacity and durability under adverse moisture and stress condition, and to improve the volume stability of a soil mass. Expansive soils are exceptionally dangerous in view of the extensive changes in volume because of swell shrink characteristics. To improve this deficiency, and consequently to improve on their field performance characteristics, they need be stabilized. There are three purposes for soil stabilization:

I. Strength improvement – this increase the strength of the existing soil to enhance its load bearing capacity.

II. Dust proofing – this is done to eliminate the dust generated by the operations of equipment's.

III. Soil waterproofing – this is done to preserve the natural or constructed strength of a soil by preventing the entry of surface water.

Basically two methods are employed in the stabilization of lateritic soil, these are:

Mechanical and chemical stabilization

1.3 Brick dust

Fig.1

Brick industries are the most important in India and other countries .because of they are the integral part of the any civil engineering construction. Based on the approximate information's available from the trusted sources it is estimated that more than 100,000 kilns in the world produce about 80 to 100 billion bricks per year. Brick powder is the waste that is obtained from the process of brick manufacturing, over burnt uneven bricks are treated as waste and another source of brick waste is demolition waste Disposal of this huge waste is a severe problem now days. Brick powder has a great ability to reduce swelling and shrinking characteristics of black cotton soil.

1.4 Lime

Using of lime for the stabilization of various types of soil is well known for the engineers from the past decades .it is

Fig.2

Found that using of lime as agent of stabilization of expansive clays reduces the plasticity and swelling when come in contact with water. Lime is a chemically reacting admixture reacts with composition of soil .mainly this process occurs in the following processes.

1. Cation exchange
2. Flocculation change of soil structure
3. Pozzolonic reaction
4. Carbonation

Table.2 chemical composition of lime

Chemical composition	%
Calcium oxide	73.22
Phosphorous oxide	0.08
Calcium sulphate	0.12
Ferric oxide	0.17
Magnesium oxide	0.74
Aluminum oxide	0.11

2. SCOPE OF PRESENT STUDY

As seen from the detailed review of the literature, the major problems governing with black cotton soil are swelling, shrinkage and heaving characteristics. The black cotton soil swells when it comes in contact with water and shrinks on drying. These soils are characterized by inherent swelling and shrinkage characteristic due to presence of montmorillonite clay mineral which exhibits volume change behavior under changes of moisture content. Because of volume change in behavior this structure constructed on such soils will undergo differential settlements, cracking in buildings or total distraction of the structure, and pavements.

Brick is traditional or modular brick obtained from brick plant. The strength of bricks depends on nature of soil used for making and the method adopted for moulding and

burning of bricks. Brick dust is a waste material obtained in brick manufacturing plant. There are numerous brick kilns which have grown over the decades in an unplanned way in different parts of the country. Tonnes of waste products like brick dust or broken pieces or flakes of bricks come out from these kilns and factories. So far, such materials have been used just for filling low lying areas or are dumped as waste materials. Thus its disposal is very important issue concerned with air pollution.

3. METHODOLOGY

There are two methods of stabilization.1.Chemica stabilization 2.Mechanical stabilization. Steps followed for the present study are listed below:

I. Black cotton soil is collected and air dried for carrying out further experiments.

II. Index engineering properties of black cotton soil is determined and listed in the table.1.

III. Various tests are conducted on lime stabilized black cotton soil and changes in the geo –technical properties of black cotton by the addition of lime and brick dust is observed.

IV. Optimum percentage of lime with various percentage of brick dust as 1.3%lime +10% brick dust 2. 3%lime +20% brick dust 3.3%lime +30% brick dust 4. 3%lime +40% brick dust is added to black cotton soil by weight for that atterberg's limits, OMC ,MDD (standard proctor test) is determined and CBR values for various percentage additional is determined.

5. TESTS CONDUCTED

Table.3

Sieve Analysis	IS 2720 (Part 4)1965
Specific Gravity	IS 2720 (Part 3)1964
Standard proctor	IS 2720 (Part 8)1983
Liquid Limit	IS 2720 (Part 5)1985
Plastic Limit	IS 2720 (Part 5)1985
Unconfined compression test	IS 2720 (Part 10)1991
California bearing ratio	IS 2720 (Part 7)1992

4.1 Test procedures

4.1.1 Specific gravity

The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc. Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air. Carried out according to IS: 2720 (part 4/sec-1) – 1980 (reaffirmed 1987) for fine grained soil.

5.1.2 Grain size analysis

Soils consist of a mixture of particles of different size, shape and mineralogy. Because the size of the particles obviously has a significant effect on the soil behavior and the grain size distribution is used to classify soils. The grain size distribution describes the relative proportions of particles of various sizes. The grain size is often visualized in a cumulative distribution graph which plots the percentage of particles finer than a given size as a function of size. The particle size distributions of black cotton soil were carried out by mechanical sieve analysis as per IS: 2720 (part 4) – 1985 method.

5.1.3 Atterberg's limits

5.1.3.1 Liquid limit

Liquid limit is the minimum water content at which soil is still in the liquid state, but has a small shearing strength against flow (liquid – plastic). Liquid limit of soil is a very important property of fine grained soil and used to classify fine grained soil. Carried out as per IS 2720 (part 5) 1985.

5.1.3.2 Plastic limit

The plastic limit is the minimum water content at which the soil particles must be able to move over one another to take up a new position and retain the new equilibrium position. The cohesion between the particles must be sufficiently high to allow the particles to maintain the moulded positions. Carried out as IS 2720 (Part 5) 1985.

5.1.4 Compaction Test

Fig.3

Compaction is a mechanical process in which the densification is achieved through the expulsion of air voids at an almost constant water content of the soil mass. For the majority of the activities adopted in the field to achieve soil compaction, the major input is the results of laboratory compaction tests- standard or modified proctor or mini compaction tests. The process of compaction, particularly of

fine grained soils seem to be a complex one, as the soil may be composed of both active and relatively inactive clay minerals. These laboratory tests generally consists of compacting soil at known moisture content into the cylindrical mould of standard dimensions using a compactive effort of control magnitude. The soil is usually compacted into the mould to a certain amount of equal layers, each receiving a number of blows from a standard weighted hammer at a specified height.

5.1.5 Unconfined compression test

Fig.4

The unconfined compression strength test is by far the most popular method of soil shear testing because it is one of the fastest and cheapest methods of measuring shear strength .the method is used primarily for saturated soils recovered from thin walled sampling tubes. The unconfined compression test is inappropriate for dry sands or crumbly clays because the materials would fall apart without some land of lateral confinement. Carried out as per IS 2720(Part-10)1991.

6. RESULTS AND DISCUSSIONS

6.1 Standard proctor test results

Table .4

Mixture	Maximum Dry Density (kN/M³)	Optimum Moisture Content (%)
BCS alone	11.51	18
BCS + 3% lime	17.81	17
BCS + 3% lime + 10% BD	18.14	15
BCS + 3% lime + 20% BD	18.23	14
BCS + 3% lime + 30% BD	18.8	13
BCS + 3% lime + 40% BD	19.1	12

Compaction characteristics of lime treated black cotton soil with various percentage of brick dust

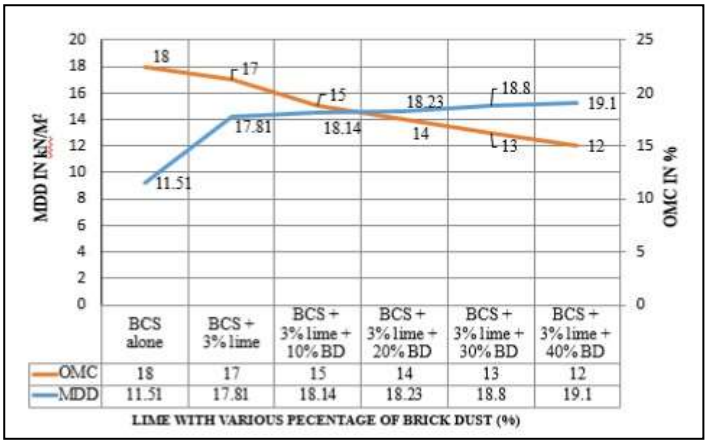

Fig.5

Variation in the compaction characteristics of lime treated black cotton soil with various percentage of brick dust

6.3 Atterberg's limit

6.2.1 Liquid limit

Table.5

Mixture	Liquid Limit (%)
BCS alone	76
BCS + 3% of Lime	62
BCS + 3% of Lime + 10% BD	61.8
BCS + 3% of Lime + 20% BD	61
BCS +3% of Lime + 30% BD	51
BCS +3% of Lime + 40% BD	40

Liquid limit values of lime treated black cotton soil with various percentage of brick dust

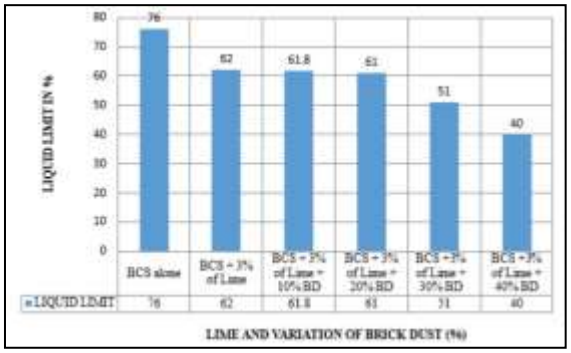

Fig.6

Liquid limit of lime treated black cotton soil with various percentage of brick dust

6.2.2 Plastic limit

Table.6

Mixture	Plastic Limit (%)
BCS alone	43
BCS + 3% of Lime	30
BCS + 3% of Lime + 10% BD	20
BCS + 3% of Lime + 20% BD	Non plastic
BCS +3% of Lime + 30% BD	
BCS +3% of Lime + 40% BD	

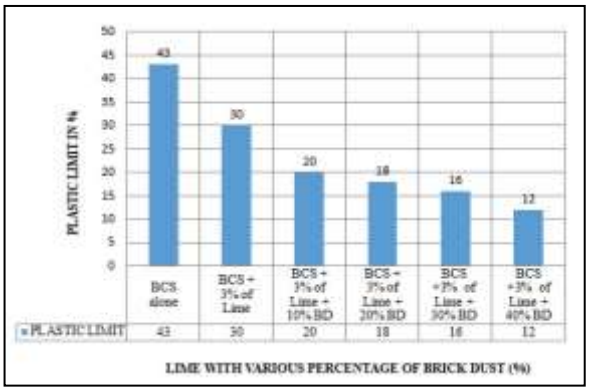

Fig.7

Plastic limit of lime treated black cotton soil with various percentage of brick dust

6.4 Unconfined compression strength test

Table.7

Mixture	Unconfined compression test kN/M²
BCS alone	145.5
BCS + 3% of Lime	156
BCS + 3% of Lime + 10% BD	166.2
BCS + 3% of Lime + 20% BD	212.2
BCS +3% of Lime + 30% BD	315.6
BCS +3% of Lime + 40% BD	395.9

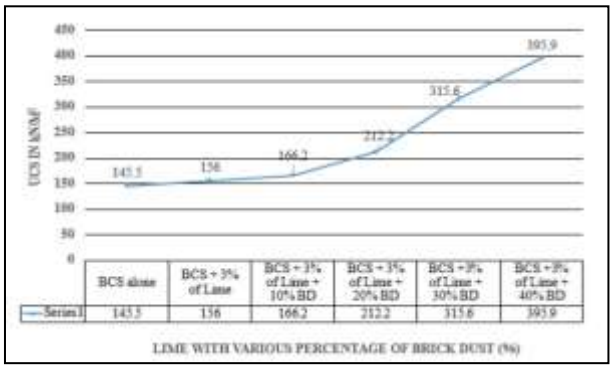

Fig.8

Graph showing unconfined compression strength of lime treated black cotton soil with various percentage of brick dust

6.5 California bearing ratio test

Table.8

Mixture	California Bearing Ratio
BCS alone	1.2
BCS + 3% of Lime	1.5
BCS + 3% of Lime + 10% BD	2.4
BCS + 3% of Lime + 20% BD	2.9
BCS +3% of Lime + 30% BD	3.5
BCS +3% of Lime + 40% BD	4.5

California bearing ratio values of lime stabilized black cotton soil with various percentage of brick dust

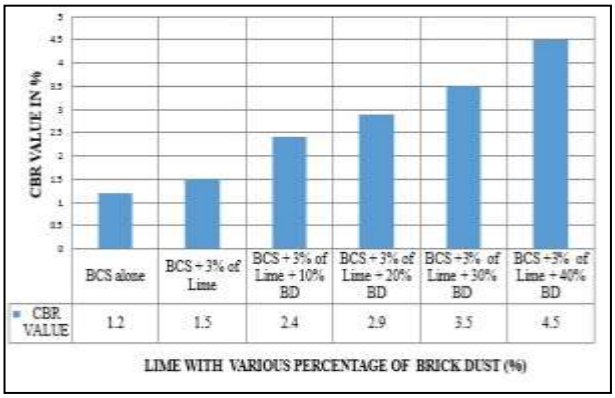

Fig .9

Graph showing variation in the CBR value of lime stabilized black cotton soil with various percentage of brick dust

CONCLUSIONS:

Based on the results, discussions and detail analysis of the data obtained from the experimental results, the following conclusions have been drawn:

- Liquid limit and plastic limit of black cotton soil is found to decrease with increase in percentage of lime and percentage of brick dust.
- Decrease in liquid limit and plastic limit with increase in brick dust content for immediate testing may be due to effect of coarser brick dust particles causes the reduction in clay content and depression of diffused double layer thickness.
- Addition of 1 to 5% lime to the black cotton soil, the maximum dry density increases up to 3% lime addition, thereafter maximum dry density decreases with increase in optimum moisture content due to the increasing demand for water by various cations and the clay mineral particles to undergo hydration reaction.
- By the addition of lime and brick dust at different percentages to soil, CBR values of soil increases up to 275%. The soaked CBR also increased by addition of lime and brick dust at different percentages.
- So use of brick dust is preferable for stabilization of black cotton soil because it gives positive results as stabilizer and also it is a waste utilization.

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